ASTRONAUTICS

Official Publication of the American Rocket Society (formerly American Interplanetary Society) 147 West 86th Street, New York City.

No. 29 New York September 1934

ROCKET EXPERIMENTS OF 1934

ACTIVITIES OF ASTRONAUTS AND ROCKETORS ALL OVER THE WORLD RECOUNTED

The summer of 1934 marked the beginning of a new era in rocket experiment. The gradual return of better times, reflected in growing membership in rocket societies; the establishment of a proving ground of the American Rocket Society on private land on Staten Island, New York; the acquisition of permanent proving stand and launching rack equipment, and a real beginning on the society's ambitious research and experimental program, marked the summer's progress.

Shesta (left), Pendray and Experimental Rocket No. 4

Other experiments also have been carried on, some of the utmost importance. A report of the experiments of Harry W. Bull, a well-known member of the Society, is published elsewhere in this issue. Dr. Robert H. Goddard, also a member of the Society, has reported the continuance of his work on the guiding, stabilization and safety of rockets, at Clark University, Worcester, Mass., where he is head of the physics laboratory. Ernest Loebell, engineer of the Cleveland Rocket Society, has been carrying on fundamental and important work toward the development of better rocket motors at the Cleveland society's grounds.

European experimenters have also been active, especially in the development of mail-rockets. A new and vigorous society, soon to start experiments, has been organized in Great Britain, under the name of the British Interplanetary Society. Its president

is Phil E. Cleator, and its headquarters Wallasey, Cheshire, England.

American Rocket Society Experiments

Three rockets were scheduled for construction this year by the experimental committee of the society. For technical reasons, Rocket No. 5 was not built, though preliminary work is progressing, and Messrs. Pierce and Carver report that it may be possible to construct it next year.

Of the other two, Rocket No. 4 was finished first, under the skillful hands of John Shesta, aided by Messrs. Manning, Best and Ahrens. It was given a preliminary test at the Staten Island proving ground on Sunday morning, June 10, which showed that some modifications would be necessary. These changes have now been made, and Rocket No. 4 will probably be shot during the first week in September, the delay being necessitated by the great number of fishing boats present in the bay near the proving ground during the summer.

The preliminary test was a fine demonstration of the utility of the society's new steel launching rack and proving stand, a permanent acquisition which will increase the ease with which future experiments can be made. It also proved the value of Mr. Shesta's new apparatus for firing rockets. This consists of an electrically-fired cartridge, so arranged that the blaze can be started from the safety of the dugout, and so timed as to fire the rocket without heating it unduly in advance.

The new turn-on valves, also perfected by Mr. Shesta, worked perfectly. By this means the valve problem appears to have been solved. A single jerk on the line opens the valves completely, and clears the rocket of all obstructions. The oxygen and gasoline valves can be opened simultaneously or in succession, as desired.

The rocket burned perfectly, but failed to fly, the reason being that the type of inlet port construction prevented a sufficiently rapid flow of the fuel. The intense and prolonged heat of the firing, instead of giving its energy to the rocket, merely burned out the motor. In repairing the rocket, a new motor was substituted, with larger nozzles and larger fuel intake, and surrounded by a water jacket. It will be remembered that the motor of Rocket No.4 has four nozzles, instead of the conventional single nozzle. It is frankly an experimental design.

Experimental Rocket No. 3

Rocket No. 3 was not finished in time for a preliminary test. Constructional difficulties, particularly the matter of obtaining leak-tight and pressure-proof welds, delayed the construction. It is now practically finished, and will be ready for shooting, probably with Rocket No. 4, early in September. The construction work was done by Bernard Smith,aided by Messrs. Pendray and Africano. The welding, a special job, was done by the Air Reduction Company at its model welding laboratory in Jersey City. This rocket is equipped with wings instead of a parachute, and has a "thrust-augmenter," the first ever used on an experimental rocket.

Scene in Valveman's Dugout During a Firing Test

Like Rocket No. 4, the third rocket has many experimental features, but its motor is of standard design, being a long-nozzled modification of the Pendray motor which performed successfully on Rocket No. 2.

Dr. Goddard's Experiments

Dr. Goddard reported to the Society that he is working on stabilizing and guiding devices for liquid-fuel rockets, and also working out means of increasing their safety. He also made the following comment on his recent work in New Mexico, information on which has hitherto been withheld:

"The work consisted in the construction and flights of a number of models designed primarily to test operation rather than to reach great heights. Flight speeds in excess of 500 miles per hour were obtained.

"It seems desirable to delay publication until the research can be completed, even though this cannot be done in the immediate future. While the results were of real importance, I do not think they would be impressive to the average person, and a final publication would lose very much by a preliminary presentation."

Cleveland Rocket Society's Plans

Word received from Charles A. Prindle, Jr., secretary of the Cleveland Society, indicates that important progress is being made toward the development of a large rocket, and that some small shots may be made yet this season.

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ROCKET AND ASTRONAUTIC BOOKS

The librarian wishes to announce, in answer to numerous queries, that the following books on rocketry are among those in the library available to members of the American Rocket Society:

Werner Brugel, "Manner Der Rakete" (German) - Collection of biographical material about rocket experimenters and astronauts.

Esnault-Pelterie, "L'Astronautique" (French) - Mathematical
"Exploration Par Fussees de la Tres Haute Atmosphere et la Possibilite Des Voyages Interplanetaires" (French) Excellent mathematical treatises on rockets and astronautics.

David Lasser, "Conquest of Space" (English) - Excellent general non-technical book on rockets and astronautics.

Dr. Vladimir Mandl, "Problem Mezihvezdne Dopravy"
"Die Rakete zur Hohenforschung" (German)
"Das Weltraum-Recht,Ein Problem der Raumfahrt" (German)

F. V. Monk and H. T. Winter, "Adventure Above the Clouds" - General material on balloon ascents and rocket possibilities.

Hermann Noordung, "Das Problem Der Befahrung Des Weltraums - Der Raketen-Motor" (German)
"Problems of Space Flying" - A translation of the above in manuscript. General - not very technical.

Jacques Perlman, "Interplanetary Travel" (Russian) - A discussion of the problems of rocket flight to other planets.
"Interplanetary Voyagers, the elements of astronautics"
"By Rocket to the Moon" (Russian) - Written for children.

Nikolai A. Rynin, "Super-Aviation and Super-Artillery" (Russian) A serious scientific study of problems of super aviation for interplanetary communication, also the development of reactive artillery for military purposes as well as interplanetary travel. Several chapters on apparatus necessary for respiration during flight, propulsion and navigation of rocket ship.
"Astro-Navigation" (Russian) and others.

The book by Hermann Oberth, "Die Rakete zu den Planetenaumen," which is considered by the German experimenter, Willy Ley, to be the greatest and most complete of the books on rockets in German, has been ordered by the library and will be available shortly.

A SURVEY OF ROCKET FUELS

(What are the possibilities of other rocket fuels beside liquid oxygen and gasoline, the combination now most commonly used by experimenters? This is a field of research of the utmost importance, as yet scarcely touched. Astronautics is pleased to present herewith a report of the brief survey recently conducted by Harry W. Bull, member of the American Rocket Society, at Syracuse, New York. Special attention is directed to the new method of obtaining reaction proposed by Mr. Bull. Perhaps other experimenters would like to try it.---Editor).

By Harry W. Bull

The major purpose of these experiments was to find a method of making cheap, simple rockets to be used in testing, guiding and stabilization apparatus. On account of the high cost of liquid oxygen and the extreme difficulty of getting it in Syracuse, the usual fuel of rocket experimenters was out of the question for my work.

1. Steam

The possibility of using steam in place of powder was attempted. A strong boiler with brazed ends was constructed which was adapted to receive nozzles of different sizes. The boiler was fitted with a gauge and recoil meter. From the tests made with this apparatus the impossibility of using steam was soon apparent.

2. Liquids of Low Boiling Point

Next liquids with low boiling points were tested with the idea that the large amount of vapor at low temperature would drive the rocket. The low exhaust temperature should make for higher efficiency.

Many liquids were tried, among them carbon disulfide, alcohol, ether, carbon tetrachloride, methyl sulfide, chlorine.

Small rockets if built very light will fly when heated with a powder flame. Larger rockets, having a boiler 3 inches in diameter and 1.5 feet long, presented a more difficult heating problem. To evaporate the liquid rapidly several arrangements were tried:

(1) A large copper heating coil was formed at the base of the rocket boiler and heated by an intensely hot magnesium flame.

(2) A large one way check valve was installed at the base which allowed the actual flames to run through the liquid but prevented the powder from getting wet before it was ignited.

(3) Tubes containing powder were placed downward in the boiler and ignited by electricity from the outside.

Several other methods of less importance were tried. All types were prone to explosions, for it seems that the greater the pressure the powder is burned under the faster it burns. The powder which evaporated the liquid was pounded with a heavy hammer into steel tubes and burned with a hot, clear flame in the open, but under pressure in a boiler it always burned at a higher speed, if it did not explode. After many explosions due to this apparent characteristic of the heating powder I ceased experimenting along these lines.

3. Miscellaneous Dry Fuels

Looking around for new types of rockets I experimented with the following:

(1) Rocket using solidified carbon-dioxide. Found to be difficult to liberate gas rapidly.
(2) Powder and paraffin mixture to give low exhaust temperature. Impractical.
(3) Rocket burning magnesium metal.
(4) Powder rocket having powder arranged in sections or tubes of small diameter to prevent rapid burning. The most successful of the rockets of this type had a powder chamber 3 inches in diameter and 6 inches long. Two nozzles 3/8 of an inch in diameter were used. The rocket was complete with shock absorbing nose, automatic parachute, etc. It behaved very well until the third test when it blew itself and the launching stand to bits.

4. Miscellaneous Liquid Explosives

I arrived at the conclusion that it was a waste of time to attempt to make a cheap powder rocket that could be used to test out new steering designs on. The only remaining fuel left to experiment with was liquid oxygen and gasoline which because of its cost was out of the question. (Ed. Note - On account of the difficulty of getting liquid oxygen at Syracuse). So it was decided to attempt to find a new fuel. Knowing relatively little about chemistry I sent notices to the chemistry departments of several universities offering a reward for a solution which would be inexpensive, explode when heated, leave little residue, be easily prepared and safe at ordinary temperatures. No replies were received.

Working in the chemical laboratory of the Forestry College, I experimented with the following combinations:

(1) Nitro-glycerine
(2) Alcohol and 30% hydrogen peroxide
(3) Turpentine and nitric acid
(4) Gasoline and various nitrates

All proved useless as far as being used in a rocket combustion chamber was concerned.

Next I read all chemistry books old and new which contained

anything pertaining to explosives. Many tests were tried but all solutions left a thick viscous residue which would have soon clogged a motor. A liquid new on the market, was brought to my attention and while it proved to be unsuccessful it lead to the discovery of a liquid which has good possibilities. Over seven hundred combinations of this liquid with others were tried before a solution which was named "Atalene" was found. Altalene has the following characteristics:

(1) Cheap
(2) Colorless
(3) Leaves no residue on exploding
(4) Explodes with great violence at a temperature of 400° F or over.
(5) Can be stored for months
(6) Safe to handle
(7) Will not backfire

At first glance Altalene would seem to be an ideal fuel, however, the heating of the solution up to the critical point offers quite a problem.

Next motors were designed especially to burn the new fuel. Five months were spent building new designs. Every week end saw me in the country trying out a new motor. Many types of fuel heaters were tried before the final plan of spraying the fuel into a magnesium flame was perfected. While testing one of the last designs a rather unfortunate accident took place. The preheating flame had been started and as I was walking away from the motor a small puddle of Altalene which had formed in the bottom of the motor by passing a defective valve exploded. A jagged section of 1 inch steel pipe was hurled into my leg,part of it continuing on out the other side.After spending my vacation in the hospital I continued these tests by remote control. Until the problem of heating the fuel is worked out by other means than powder I do not think an absolutely safe rocket will be attained.

5. Entirely New Reaction Methods

An entirely new means of securing a reaction was next tested. The rocket was made up of a series of chambers the ends of which consisted of steel disks fastened together by a 1/4 inch diameter steel rod. The chambers were arranged to explode in series, blowing the steel disks downward with great velocity. Knowing the weight of the disk and its velocity and also the weight of the complete rocket it is a simple matter to find the energy of the recoil. Although this type of rocket works, it leaves much to be desired in the line of safety.

A series of tests now followed which I believe are original in the field of reaction. They dealt with a form of impact-impulse reactions which are created mechanically. The apparatus if placed in a box in space would move without the use of a jet of any sort, it being propelled by a reciprocating motion of two weights. The truth of the theory may be easily proven by a very simple apparatus.

The theory is that a large weight with a low velocity (if

stopped by springs) will yield more foot pounds of energy than a small weight with a high velocity being stopped by impact, even though both were given the same initial force. A simple illustration: Let us assume you are in the center of a room in space. One wall is elastic and the opposite one solid. In your hands are two balls one heavy and the other light and you throw them with the same force at the same time. The heavier one hits the elastic wall with an impulse and a large amount of energy is given to the room in that direction. The lighter one having the same energy hits the solid wall but its energy is dissipated in heat and distortion. If there could be found a method whereby the kinetic energy of the lighter ball could be effectively utilized the room would move in the other direction.

MISCELLANEOUS ROCKET NEWS

Harry W. Bull has just written and published an interesting booklet entitled "How to Build and Run a Rocket Ship". Copies may be obtained for fifty cents each, directly from Mr. Bull, 326 Hickok Avenue, Syracuse, New York, or from the librarian of the American Rocket Society.

* * *

A new rocket society, the Peoria Rocket Association, has been organized in Peoria, Illinois. Its president is Ted S. Cunningham; its address, 301 North Madison Street.

* * *

A program of rocket research is being formulated by the British Interplanetary Society, according to word just received from its president, Phil E. Cleator. The experiments will probably be carried on under the direction of Mr. Cleator and H. Grindell Matthews, noted British inventor.

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An international agreement for the rapid interchange of information between the American, German and British societies is being worked out, with a view to forming an international rocket society should the number of national societies and the information involved justify it. In the meantime, a mutual agreement to exchange information is in operation. Efforts are being made to induce the Austrian, Russian and French experimenters to join this arrangement for the furtherance of rocketry.

"THE CONQUEST OF SPACE"

Some readers have experienced difficulty in obtaining copies of David Lasser's excellent book on rocketry and astronautics "The Conquest of Space" at bookstores. The library of the American Rocket Society now has a limited number of copies, to be sold to members at $2.50 each, and to non-members at the regular bookstore rate of $3.00. Address inquiries to Lee M. Gregory, librarian, 147 West 86th Street, New York City.

ROCKET EXPERIMENTS OF 1934
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"We may possibly send up a rocket this summer," Mr. Prindle reported. "However, it will depend entirely on the tests we shall make during the next few weeks. It is not our ambition to merely send a rocket up, but to perfect it on the ground first. So far we have discarded two motors because of their inefficiency."

The Austrian Post Rocket

Much interest has been aroused among rocket enthusiasts and others by reports of the "rocket-post" established near Graz, Austria, by Ing. Fritz Schmiedl. Word recently received by the Society from Herr Schmiedl and others familiar with the project indicate that the rockets used are powered with dry fuels. The mail is shot over a small mountain separating the towns of Schockel and Radegund, a distance apparently of less than a mile, and the cargo comes down by parachute.

About twenty shots have been made,some successful, others not. The mail transported is mainly that sent by stamp collectors, and a special series of stamps has been issued for the "rocket-post". European experimenters appear to consider it an interesting, but not particularly important experiment, though it may yield much valuable data about rocket flight. Careful records are being kept by Herr Schmeidl.

News of German Experimenters

Following the Hitler revolution in Germany, and partly due to internal dissention, the famous Verein fur Raumschiffahrt, at one time the largest society of astronauts and rocket enthusiasts in the world, was dissolved. It has been succeeded by a new organization, which bears the difficult name of E. V. Fortschrittliche Verkerstechnik. Willy Ley, secretary and vice-president of the old Verein, has like offices in the new organization, and is its moving spirit. The president is Major Hans Wolf von Dickhuth-Harrach, well known German aeronaut. It is expected that active experimental work will begin soon, carrying on the fine achievements of the old society at its Rakentenflugplatz.

THE BEST METALS FOR ROCKETS

(Bernard Smith, co-designer and builder of the society's Rocket No. 3, has just completed a survey of metals available for rocket construction for the experimental committee. His report, summarizing metallurgical information for the first time arranged and evaluated from the point of view of the rocket builder, is presented herewith.---Editor).

By Bernard Smith

The structural metals eligible for rocket practice, under its stringent requirements, are extremely few and must be selected principally for their high specific tensile strength. (The specific tensile strength of any metal is equal to its tensile strength, divided by its specific gravity, and is used as a direct index when comparing metals for strength on a weight basis instead of the customary cross-sectional one).

From Table A, the inability of metallurgists to increase this index figure much beyond that for the best iron alloy (Cr-Mo-Steel) is quite evident. What an investigation of the remaining metals, after magnesium, may yield, is open to speculation. Basing predictions on hardness which to some extent is related to strength, all other metals, with the possible exception of Beryllium will have a specific tensile strength lower than that for steel, even when alloyed.

Table A
Light metals compared with iron.

Metal	Sp.Gr.	Hardness	Melting Pt.°Cen.	Corrosion Resistance In Air	Malleability	Alloyed Ten.Str. lbs/in²	Alloyed Specific Ten. Str.
Iron	7.86	4.5	1525	Poor	Good	175,000	22,100
Aluminum	2.70	2.9	658	Good	Good	60,000	21,400
Magnesium	1.72	2.0	651	Fair	Fair	40,000	22,200
Beryllium	1.84	6.5	1280	Good	Bad		
Lithium	.53	0.6	180	Bad	Good)		
Sodium	.97	0.4	97	Bad	Good)		
Potassium	.85	0.5	63	Bad	Good)	- Decompose water	
Rubidium	1.52	0.3	39	Bad	Good)	and liberate	
Calcium	1.56	1.5	810	Bad	Good)	hydrogen	
Titanium	4.87	7.	1795	Good	-		

Apparently then with the exception mentioned, little or nothing is to be gained through the use of light alloys, on the basis of tensile strength. Actually however (especially in motor castings, where construction is always aimed at rigidity and resistance to distortion) a very large percentage of structures are designed for <u>stiffness</u>.

Table B, shows how decidedly superior the light metals are in this respect. The figures given have been calculated for metal struts of constant length and width but varying thickness. Stiffness in this case is equal to the thickness cubed times Young's Modulus of Elasticity.

Table B
Relative Stiffness

(Steel is arbitrarily given a stiffness, weight and thickness of 100)

Alloy	Relative Weight	Young's Modulus of Elasticity lbs/in^2	Stiffness	Thickness	Weight
Chrome-Mo-Steel	13.2	30,000,000	100	100	100
Duralumin	4.5	10,000,000	100	144	50
Dowmetal (Magnes.)	3.	6,500,000	100	165	38
Beryllium	3.1	40,000,000	100	91	21
Lithium	1.	3,000,000	100	215	17

The first three alloys are available commercially. The properties of the first two, iron and aluminum are familiar to everyone. The third, magnesium, not so commonly known, has the appearance of aluminum plus much better machineability. Their electrical and thermal conductivity, weight for weight are equal. Magnesium lends itself to welding, successfully, still its low kindling point imposes certain restrictions on its use and is what really keeps it from being used extensively, though its good heat conductivity helps to allay this danger considerably.

Beryllium, a congener of magnesium, would if its ores were more profuse, be a far more popular metal. A summary of its characteristics reads like the description of an imaginary metal. As light as magnesium, harder than steel, with approximately the same melting point and a resistance to corrosion equal to aluminum, it seems as though aeronauts could ask for little more in the way of a metal.

Some of its qualities however will have to be improved before it can be made completely adaptable. It is much too brittle to withstand bending or drawing without being first raised to temperatures where oxidation takes place rapidly enough to cause large losses in metal. Metallurgists though, offer definite promise of it attaining satisfactory working properties when properly alloyed. The rocket's motor will most certainly be made mainly of this metal in the future.

Lithium, as a light structural metal, presents some possibilities. It is so light (lightest of all solids at ordinary temperatures) that it can retain its low specific gravity as a factor even after being alloyed sufficiently to lessen its activity. This possibility is the attraction offered to metallurgists despite the fact that it belongs to the alkali metal group. Contributing to its choice as the only logical alkali metal for further experimentation along this line, is its rank as highest in hardness and melting point in this series. It is also ductile enough to be drawn into fine wire. On the basis of weight it is a better electrical conductor than any other metal and for cross-section is twice as good as Beryllium and one half as good as Magnesium. The figure given for its modulus of elasticity is only an estimated one based on its probable properties when alloyed sufficiently to prevent excessive corrosion.

Titanium, a little known metal, has been inserted in our list principally because of its wide distribution in nature. In order of abun-

dance the metals are: aluminum, iron, calcium, sodium, potassium, magnesium, titanium.

It would seem that a metal definitely in the light metal class and more profuse than copper, zinc, tin, lead, nickel, chromium, lithium or beryllium should be better known. Such a high melting point and hardness could be useful in rocket construction.

Conclusions

We have then, as possibilities for our blast chamber,two light metals possessed of high melting points, besides numerous other heavy ones, among which are tungsten, tantalum, molybdenum. For wire bracing we can do no better than resort to steel. For tanks, beams and struts, which will constitute most of the practical rocket structure, we may yet have at our disposal a lithium-beryllium alloy of great strength.

Already a Be-Li-alloy lighter than calcium has been created, with far better qualities. Reports concerning this alloy unfortunately are very meagre. The information available gives its ratio of constituents as Be 75% - Li 25%, and its specific gravity as 1.5. Claims for its corrosion resistance and malleability are high.

Combinations of these two metals are quite logical, for we may expect lithium to impart to such an alloy lightness and pliability and beryllium high melting point, high kindling point and a tenacious inert protective covering of beryllium oxide over its surface much as chromium gives to chrome steel. An alloy of beryllium with lithium is more feasable than one with magnesium, calcium or any other alkali metal, as shown by their melting and boiling points.